

## Powering the Future: Strategic Governance for Sustainable Energy Systems

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### Abstract

India stands at a crucial point in its energy transition journey, striving to balance economic growth with environmental responsibility. This paper explores how strategic governance can help build a sustainable energy future, especially in a diverse and rapidly developing country like India. It emphasizes the importance of integrated policymaking, inclusive public engagement, and innovative technologies to ensure long-term energy security. By examining India's current frameworks, success stories, and challenges, the study provides insights into how adaptive, transparent, and collaborative governance can accelerate the shift toward renewable energy. The paper also highlights how India's efforts align with global sustainable development goals and offers policy suggestions that can guide both national and regional energy strategies. The impact of this study lies in its practical relevance, especially for policymakers, administrators and stakeholders involved in planning India's green energy roadmap.

*Keywords:* sustainable development, power and energy, renewable energy.

## Introduction

The way we produce and consume energy is transforming faster than ever before. With rising concerns about climate change, pollution, and fossil fuel dependency, the global energy sector is witnessing a shift toward renewable and sustainable alternatives. This transition is

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urgent and challenging for a country like India, which is home to over 1.4 billion people and is one of the world's fastest-growing economies.

Sustainable energy refers not just to the use of clean sources like solar, wind, hydro and biomass, but also to how energy is governed, distributed, and used efficiently. Energy systems must now be technically reliable, environmentally responsible, economically affordable and socially inclusive. In this context, strategic governance becomes the backbone of energy transformation. It ensures that the shift to sustainable sources is planned, transparent and participatory, involving everyone from government bodies to rural communities.

India has made significant strides in this area. The nation is actively reforming its energy landscape. The launch of the National Action Plan on Climate Change (NAPCC) and its missions such as the National Solar Mission, represent India's commitment to green growth.

However, the road is far from smooth. Many regions still face electricity shortages and the affordability of clean energy remains a concern for lower-income groups. There is also a need to align central and state policies more effectively. Moreover, the governance of energy systems must adapt to complex challenges, including rapid urbanization, environmental degradation and technological disruptions.

Strategic governance plays a key role in managing this complexity. It involves long-term planning, data-driven policymaking, effective regulation, public-private partnerships, and inclusive stakeholder engagement. In India, this also means navigating political diversity, balancing economic development with environmental protection and empowering local institutions.

This paper focuses on the strategic governance mechanisms that can support India's transition to sustainable energy systems. It aims to answer critical questions such as: What policies and institutions are driving India's energy shift? How can technology and innovation be better integrated into governance? What role do communities and local governments play? And what financial and regulatory tools can make this transition faster and fairer?

### **Strategic Governance in the Context of Sustainable Energy**

Strategic governance refers to the coordinated, forward-looking efforts of governments, institutions, and stakeholders to shape systems in a way that ensures long-term goals are met efficiently and fairly. In the context of sustainable energy, governance goes beyond regulation as it includes vision-setting, planning, implementation, monitoring, innovation and public engagement. It ensures that energy systems are not only technically robust but also socially and environmentally responsible.

Traditional governance often operates in silos, where decisions are made in isolation and focus on short-term outcomes. Strategic governance, however, is integrated and long-term. It brings together various sectors such as energy, environment, economy, transport and housing to plan and implement cohesive energy strategies. In energy systems, this means aligning national energy policies with local development goals, adapting to market changes, and anticipating future technological shifts.

Key elements of strategic energy governance include:

- Policy coherence across sectors and government levels
- Stakeholder engagement in planning and decision-making
- Data and evidence-based decision-making
- Long-term vision with flexibility for innovation
- Strong institutional coordination and accountability

Governance must be agile and participatory to adapt to rapid technological change and shifting social priorities. For instance, decentralised renewable energy systems (like rooftop solar or community biogas plants) demand governance that supports bottom-up planning and local innovation.

### ***Strategic Governance and Sustainable Energy: The Indian Experience***

India's journey towards sustainable energy reflects several strategic governance practices, though there is room for improvement. The Government of India, through its ministries and regulatory bodies has adopted a mix of top-down directives and bottom-up partnerships to steer the energy transition.

One major example is the National Electricity Plan, revised every five years by the Central Electricity Authority (CEA), which outlines India's future power generation strategy. It sets clear targets for renewable energy integration, energy efficiency and demand forecasting. This aligns with the national goal of achieving net-zero emissions by 2070. It emphasizes research, skill development, and modern transmission technologies, aiming to position India as a leader in clean energy by 2047.

India's Energy Conservation Act (2001) and the creation of the Bureau of Energy Efficiency (BEE) showcase how regulatory governance can push for energy savings across industries, buildings, and appliances. The BEE's Star Labelling Programme, for instance, has become a household name for promoting energy-efficient products.

Another strong example of strategic governance is the International Solar Alliance (ISA), co-founded by India, which positions the country as a global leader in solar energy collaboration and policy innovation.

### ***Adaptive and Inclusive Governance***

Strategic governance in India must also be adaptive, capable of learning from experience and adjusting based on new knowledge or ground realities. The rollout of solar power in India offers a clear example. Early solar policies focused on large utility-scale plants, but over time, the government began to promote decentralised rooftop systems and solar pumps for farmers (under the PM-KUSUM scheme), learning from implementation gaps and evolving needs.

Inclusivity is another cornerstone. Women, tribal communities, and rural populations often face energy exclusion. Strategic governance frameworks must therefore ensure these voices are heard in planning and benefit-sharing. For example, involving local self-government bodies (Panchayats) in microgrid planning can improve project acceptance and sustainability.

### **India's Policy and Institutional Framework for Sustainable Energy**

India's approach to energy policy has evolved significantly over the past two decades, moving from a supply-driven, fossil-fuel-dependent model to one that is increasingly guided by sustainability, equity and innovation. This transformation has been made possible by a robust institutional framework and several targeted policies.

### Key National Policies Driving Sustainable Energy:

- **National Electricity Policy (NEP):** The NEP provides broad guidelines for the development of the power sector. It promotes energy efficiency, rural electrification and renewable energy. It also pushes for competition, transparency and consumer protection.
- **National Action Plan on Climate Change (NAPCC):** Launched in 2008, NAPCC includes eight missions, two of which the **National Solar Mission (NSM)** and the **National Mission for Enhanced Energy Efficiency (NMEEE)** directly address the energy sector. These missions promote large-scale solar energy deployment and incentivise industries to adopt energy-saving practices.
- **National Energy Policy (NEP) 2017 – Draft:** Although not officially adopted, the draft NEP by NITI Aayog outlines India's vision of achieving universal access to energy, affordability, sustainability, and energy security. It encourages a shift to cleaner fuels, smart grids, and storage technologies.
- **Ujjwala and Saubhagya Schemes:** Although not directly renewable, these schemes contribute to sustainable energy access. Ujjwala has enabled cleaner cooking by distributing LPG connections to low-income households, while Saubhagya ensured nearly universal household electrification.

### *Major Institutions in India's Energy Governance*

India's energy governance is complex, involving multiple ministries, regulatory bodies and public-sector undertakings (PSUs). Strategic coordination among them is essential for a smooth energy transition.

- **Ministry of Power (MoP):** Responsible for electricity generation, transmission, and distribution. It oversees the Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC), and Power Grid Corporation.
- **Ministry of New and Renewable Energy (MNRE):** MNRE is the nodal body for formulating and implementing renewable energy policies and programmes. It plays a critical role in project financing, subsidy administration, and international cooperation.

- **NITI Aayog:** As a policy think tank, NITI Aayog develops long-term energy strategies and publishes the Energy Policy and India Energy Security Scenarios. It also guides states on integrating renewables and adopting sustainable technologies.
- **Bureau of Energy Efficiency (BEE):** An autonomous body under the Ministry of Power, BEE implements energy conservation laws, labelling programmes, and the PAT scheme. It also conducts capacity-building for industries and institutions.
- **State Electricity Regulatory Commissions (SERCs):** At the state level, SERCs determine electricity tariffs, approve power purchase agreements, and promote renewable energy through regulatory mandates like Renewable Purchase Obligations (RPOs).
- **Energy Efficiency Services Limited (EESL):** A joint venture of PSUs under the Ministry of Power, EESL implements large-scale energy efficiency projects, such as LED distribution under the UJALA programme and efficient agricultural pump schemes.
- ***Legal Framework Supporting Sustainable Energy***
- **Electricity Act, 2003:** The cornerstone of India's power sector reforms, the Electricity Act promotes competition, protects consumer interests, and enables renewable energy promotion. It also provides for Open Access, allowing large consumers to buy green power from producers.
- **Energy Conservation Act, 2001:** This Act led to the formation of BEE and mandates the development of energy efficiency standards for appliances, vehicles, and industries.
- **Proposed Electricity (Amendment) Bill, 2022:** This Bill proposes delicensing electricity distribution and mandating stricter RPOs. If passed, it would modernise India's power market and make room for greater private and green investments.
- **Smart Grids and Digital Governance in India's Energy Transition**
- As India advances toward sustainable energy goals, technology is playing an increasingly important role in transforming the way electricity is generated,

distributed and consumed. One of the most critical innovations in this transition is the **smart grid**, an intelligent electricity system that uses digital tools to manage supply and demand more efficiently, integrate renewable sources and empower consumers.

- *What is a Smart Grid?*
- A **smart grid** refers to an upgraded electricity network that uses advanced sensors, digital communication, and automation to monitor and control energy flow. It can respond in real-time to changing demands and disruptions, making the grid more reliable, efficient and resilient.

Smart grids allow for:

- **Two-way communication** between utility companies and consumers
- **Integration of renewable energy sources** like solar and wind
- **Real-time monitoring and control** of electricity flow
- **Efficient demand-side management** and energy saving
- **Reduced power losses** and faster fault detection

### *Why India Needs Smart Grids?*

India's power sector faces several structural issues high transmission and distribution (T&D) losses, voltage fluctuations, overloaded substations, frequent blackouts and poor financial health of DISCOMs. Smart grids can help address these challenges by:

- **Reducing technical losses** through real-time fault detection
- **Improving load management** with time-of-day pricing and demand forecasting
- **Ensuring grid stability** in areas with high renewable energy penetration
- **Facilitating net metering** and rooftop solar connections
- **Enhancing consumer control** through smart meters and mobile apps

For instance, India's average T&D loss is over **20%**, much higher than the global average of 6–8%. Smart grid technologies can bring this down significantly.

### ***National Smart Grid Mission (NSGM)***

To promote smart grid development in India, the Ministry of Power launched the **National Smart Grid Mission (NSGM)** in 2015. NSGM provides funding, technical support and policy direction for deploying smart grid projects across the country.

Key features of NSGM include:

- Developing **pilot smart grid projects** in urban and semi-urban areas
- Promoting **smart metering infrastructure (AMI)**
- Capacity building through **Smart Grid Knowledge Centers**
- Supporting DISCOMs in **grid modernization and automation**
- Coordinating with state governments and regulators

Some of the early pilot projects under NSGM were implemented in **Mysore, Varanasi, Chandigarh and Delhi**, focusing on smart metering, peak load management, and outage response systems.

### ***Smart Meter National Programme (SMNP)***

The **Smart Meter National Programme**, led by **Energy Efficiency Services Ltd. (EESL)**, aims to install millions of smart meters across India. These meters help consumers track real-time electricity usage, enable prepaid billing, and alert utilities about power theft or outages.

### ***Role of Digital Governance***

Smart energy systems are powered not just by physical devices but also by **digital governance**—the use of software platforms, data analytics and AI for decision-making in the power sector.

Key digital governance tools include:

- **SCADA (Supervisory Control and Data Acquisition):** Used for real-time monitoring of substations and grid assets
- **Geographic Information Systems (GIS):** Help plan and monitor power distribution in rural and urban areas
- **Demand Response Systems:** Adjust power supply based on demand patterns
- **Block chain for energy trading:** Enabling peer-to-peer energy sharing between solar users and buyers
- **Mobile apps for consumers:** Track energy consumption, pay bills, lodge complaints

The Government's **Digital India** initiative complements these efforts by ensuring digital infrastructure, internet connectivity and data protection which are all crucial for managing smart grids.

### *Delhi's Smart Grid Journey*

**BSES Yamuna Power Limited (BYPL)** in Delhi is a leading example of smart grid adoption. It implemented smart meters across its service area, reducing power theft and improving bill collection. Consumers can view usage patterns on a mobile app and receive alerts during peak hours. Load management systems also reduce pressure on transformers during summers, avoiding blackouts.

Delhi's experience demonstrates that even in dense urban settings, smart grids can create real impact if executed well with consumer cooperation.

### *Challenges in Implementing Smart Grids in India*

Despite the promise, the rollout of smart grids in India faces several hurdles:

1. **High capital costs:** Smart meters, automation systems and IT infrastructure require upfront investments that many DISCOMs cannot afford.
2. **Cybersecurity concerns:** Digitising the grid makes it vulnerable to hacking and data breaches.

3. **Low consumer awareness:** Many consumers don't yet understand how smart meters' work or how to use them for energy savings.
4. **Interoperability issues:** Lack of common standards among vendors makes system integration difficult.
5. **Data privacy and storage:** Ensuring secure and ethical use of consumer energy data is still a work in progress.

### ***Building Smarter Energy Systems***

To overcome these challenges and accelerate smart grid adoption, India needs:

- **Public-private partnerships** for financing and innovation
- **Capacity building** for DISCOM staff, engineers and local authorities
- **Regulatory reforms** for time-of-day tariffs and net metering
- **Awareness campaigns** to involve citizens in demand-side management
- **Cybersecurity standards** for smart grid components and data platforms

The **Smart Cities Mission**, which overlaps with the smart grid agenda, should also include energy efficiency and renewable energy integration as a core priority.

### **Digital Governance and Inclusivity**

India's digital transition must be inclusive. Smart grid systems should benefit not only urban elite consumers but also rural populations, small towns and low-income households. For example, prepaid smart meters can help daily-wage earners manage their electricity usage more effectively, avoiding sudden disconnections due to unpaid bills.

Data collected from smart meters can also guide government policies for instance, identifying under-served areas for solar installations or planning future energy access initiatives.

### **Administrative and Strategic Challenges in Sustainable Energy Governance**

India has made remarkable strides in building a foundation for sustainable energy. Yet, transforming vision into reality is not without its challenges. These obstacles are not only

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technical or financial in nature but also deeply rooted in **administrative inefficiencies**, **institutional gaps**, and **strategic misalignment**. Addressing these challenges is critical to ensuring that sustainable energy transitions are inclusive, efficient and lasting.

➤ *Institutional Fragmentation and Lack of Coordination*

One of the most persistent challenges in India's energy governance is the **fragmentation across ministries and agencies**. The Ministry of Power, MNRE, MoEFCC (Ministry of Environment, Forest and Climate Change) and state-level departments often operate in silos. This lack of integration results in overlapping policies, contradictory schemes and delayed project execution.

For example, a solar project may need clearances from multiple agencies such as land approvals from local governments, subsidies from MNRE, grid connectivity from the state utility, leading to procedural delays and investor uncertainty.

In order to deal with such challenge, we must:

- Establish inter-ministerial task forces for renewable energy and smart grid projects
- Introduce a **single-window clearance system** for green energy projects
- Strengthen coordination between Centre and States via NITI Aayog or inter-state energy councils

*2. Land and Environmental Clearance Issues*

Renewable energy projects, especially solar parks and wind farms, require large tracts of land. Acquiring land without affecting local communities or ecosystems is a sensitive issue in India. Delays in environmental clearances or resistance from local populations can stall projects.

The challenge is to balance the need for clean energy with **ecological conservation** and **social equity**.

To deal with it, we must:

- Promote **agrivoltaics** i.e. combining agriculture and solar panels on the same land

- Use **wastelands and degraded lands** for solar parks
- Ensure community consultation and fair compensation through Panchayats and local governance bodies

### *3. Capacity Constraints at the Local Level*

State and local governments often lack the technical expertise and human resources to implement and monitor energy programs effectively. This is especially true in rural areas where decentralized renewable energy systems are needed most. Therefore, the focus should also be to:

- Conduct regular **training programs for local officials and technicians**
- Empower district and block-level agencies with **energy cells** and planning tools
- Involve academic institutions and NGOs for community engagement and capacity building

### *4. Technology and Infrastructure Gaps*

Even though smart grids and digital platforms are being adopted, the pace is slow due to lack of infrastructure and technical readiness in many regions. Power outages, poor internet connectivity and low IT awareness hamper digital governance tools like smart meters or mobile apps.

Additionally, storage technologies like batteries, which are essential for solar and wind energy reliability are still expensive and underdeveloped in India. Therefore, we must:

- Prioritize investment in **energy storage systems and grid modernization**
- Expand **internet access and mobile connectivity** in rural and peri-urban areas
- Foster domestic manufacturing of green tech through the **Production Linked Incentive (PLI)** scheme

### *5. Social Equity and Energy Justice*

India's energy transition must not leave anyone behind. Rural areas, marginalized communities, and women often have limited access to reliable and clean energy. Moreover, the loss of jobs in coal-dependent regions raises concerns about a **just transition** for workers and communities.

Without inclusive policies, the energy shifts risks widening social and economic gaps. Therefore, there should be:

- Design **targeted subsidies and energy access schemes** for vulnerable populations
- Support retraining programs for workers in fossil fuel industries
- Promote **women-led energy enterprises** and community ownership models in renewable energy

#### ***6. Data Management and Cybersecurity***

As more energy systems become digital, there's a growing need for secure and ethical handling of consumer data. Smart meters, IoT devices and energy management platforms collect vast amounts of data that, if misused or breached, could pose serious risks.

India currently lacks comprehensive legal frameworks for **energy data privacy and cybersecurity**. Therefore, there is a need to:

- Develop a national framework for **energy data governance**
- Enforce **cybersecurity standards** for all energy IT infrastructure
- Involve experts from tech, legal, and public sectors to ensure balanced regulation

#### **Future Pathways and Strategic Recommendations for Powering a Sustainable India**

India stands at a crucial juncture in its energy journey. With rising energy demand, a growing population, and ambitious climate goals, the country must strike a balance between **economic development, energy security, and environmental sustainability**. Strategic governance and smart planning are key to navigating this complex path. This section outlines the way forward by focusing on **holistic strategies, inclusive policies and technology-driven reforms**.

### ***1. Towards an Integrated Energy Governance Framework***

India's energy landscape is vast and diverse, but also fragmented. Ministries, regulatory bodies, and public-sector undertakings (PSUs) often work in silos. This fragmentation slows down decision-making, leads to duplication of efforts, and causes confusion among investors and consumers alike.

#### **Recommendations:**

- Establish a **National Sustainable Energy Council (NSEC)** under NITI Aayog to bring together all key stakeholders—central ministries, state departments, regulators, industry, and civil society.
- Encourage **coordinated energy planning** at the state level through integrated resource plans (IRPs) that align with national targets.
- Promote **data sharing and transparency** across agencies to facilitate better planning and monitoring.

### ***2. Accelerating Renewable Energy with a Localised Approach***

While national-level policies have driven India's renewable growth, **localised strategies** are now essential to ensure equitable energy distribution and resilience. States like Rajasthan, Gujarat, Tamil Nadu, and Maharashtra have led solar and wind adoption, but others lag behind.

#### **Recommendations:**

- Incentivise **state-specific renewable energy targets**, considering local resources and demand.
- Promote **community-owned solar and wind projects**, especially in rural and tribal areas, ensuring local employment and participation.
- Scale up programs like **PM-KUSUM** for solar pumps and **Rooftop Solar** with special focus on MSMEs and residential consumers.

**Example:**

The Dharnai Solar Village in Bihar, developed by Greenpeace India, is a successful example of decentralised solar micro grids empowering rural communities.

***3. Smart Grids and AI-Based Energy Management***

Smart grids and digital platforms are the backbone of future-ready energy systems. They enable demand-side management, real-time fault detection, and better integration of renewables.

**Recommendations:**

- Deploy **AI and machine learning** for predictive maintenance, energy forecasting, and consumer profiling.
- Expand **smart meter penetration** across all consumer categories and link them with mobile apps and online dashboards.
- Use **IoT-enabled devices** for dynamic pricing and energy automation in urban areas.

In Uttar Pradesh, smart meters deployed by Energy Efficiency Services Limited (EESL) have significantly reduced losses and improved revenue collection, demonstrating how digital tools can reform traditional power systems.

***4. Energy Storage and Grid Flexibility***

To ensure 24/7 green power, especially from intermittent sources like solar and wind, **energy storage solutions** are essential. Currently, the lack of affordable storage restricts renewable usage beyond peak generation hours.

**Recommendations:**

- Invest in **battery manufacturing hubs** under the Production Linked Incentive (PLI) scheme.
- Promote research in **alternative storage technologies** like pumped hydro, hydrogen storage, and compressed air systems.

- Create **regulatory incentives** for DISCOMs and private firms to adopt storage-linked power procurement.

### ***5. Just Energy Transition and Inclusive Planning***

India's shift away from fossil fuels must be **socially just and inclusive**. Coal-dependent states like Jharkhand, Chhattisgarh, and Odisha face employment and economic risks. Women, small farmers, and informal workers must also be included in the energy transition story.

#### **Recommendations:**

- Create a **Just Transition Fund** to support skill development and job creation in green industries.
- Design **inclusive energy access programs** for remote and underserved areas.
- Encourage **women-led renewable energy enterprises** through subsidies and capacity-building support.

#### **Example:**

SEWA (Self-Employed Women's Association) in Gujarat trains women to install and maintain solar systems, proving that gender-inclusive energy models are both practical and impactful.

### ***6. Education, Awareness, and Capacity Building***

For any energy policy to be successful, public participation and understanding are essential. Many citizens, especially in rural areas, are unaware of schemes like solar rooftop subsidies or the benefits of LED lighting and energy conservation.

#### **Recommendations:**

- Integrate **energy literacy** into school curricula and community programs.
- Conduct **awareness campaigns** through mass media, local NGOs, and youth organisations.

- Partner with institutions like **TERI, IITs** and **NIITs** to develop training modules for government officials and local technicians.

### **7. Robust Data, Cybersecurity, and Regulation**

With digital tools becoming central to energy governance, protecting consumer data and energy infrastructure from cyber threats is non-negotiable.

#### **Recommendations:**

- Enforce **national cybersecurity protocols** for all smart grid and energy platforms.
- Develop a **Central Energy Data Repository** to guide policy decisions and track progress.
- Implement **third-party audits and performance benchmarks** for DISCOMs and regulators to improve accountability.

### **India's Roadmap to a Green Future**

India's ambition to become a global clean energy leader is not only achievable but also necessary for its economic, social, and environmental well-being. The foundations have been laid through large-scale renewable deployment, policy initiatives, and digital innovations.

But the next phase of growth demands **strategic governance** that is:

- **Coordinated across all levels of government**
- **Inclusive of all stakeholders**
- **Responsive to changing technologies and demands**
- **Grounded in the principles of equity and justice**

### **Conclusion**

Through integrated planning, transparent institutions, empowered local bodies, and strong public participation, India can power its future sustainably lighting every home, fuelling every innovation, and preserving its environment for generations to come.

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